

control of the northern hemisphere of the sun. Since the sequence or procession of the highs and lows crossing the United States corresponds always to either the direct or the inverse types, allowing for the inevitable looseness of structure in the circulation, it follows that the solar action has the power to invert the entire atmospheric movement, not only in the United States but also over the whole hemisphere of the earth (Amer. Met. Journ., Sept., 1893, curve 15). The inference seems very simple that if this polar magnetic field can maintain an order of highs and lows and can invert the order, then this magnetic field either directly or indirectly is chiefly concerned in the production of the cyclonic and anticyclonic systems. By as much as this is true, grave doubt is thrown upon the soundness of the convectional hypothesis of Ferrel, and the dynamic or driven-eddy theory of Hann to account for our primary meteorological phenomenon. The truth seems to be that the atmosphere of the earth

is under the influence of four great systems of impressed forces:

1. The stress of the earth's gravitation.
2. The deflecting forces of the earth's rotation.
3. The equatorial radiant energy of the electromagnetic field.
4. The polar magnetic radiant energy from the polar regions of the sun.

The first and second are constant forces; the third has a steady diurnal and annual period from astronomical conditions; the fourth is very variable and loosely constructed, depending upon solar action, and yet is the system by which weather conditions are chiefly produced. Heretofore the meteorological problem has sought its solution by combinations of the three systems of forces mentioned, but it is clear that one of the most influential sets of impressed forces has been entirely neglected.

SPECIAL CONTRIBUTIONS.

I.—TORNADO, MARCH 26, AT ALBANY, N. Y.

Mr. Alfred F. Sims, Weather Bureau observer at Albany, N. Y., reports on the tornado of March 26, at that place, as follows:

Thunder first heard 2.58 p. m.; loudest, 3.06 p. m.; last heard, 3.06 p. m. Storm came from southwest, moved southeasterly to the Hudson River south of station, thence north. Temperature before storm, 47°; temperature afterward, 43°; direction of wind before, south; afterward, south. At 2.50 p. m. the clouds to the north and west of this station assumed a slate color, and at 2.55 p. m. the lower portion of the cloud formation took on a peculiar yellow tint at the bottom (such a tint as would result from the presence of a large quantity of sand particles). At 2.58 p. m. some rain fell and distant thunder was heard; the rain came from the southwest. As the heavy cloud formation neared the station, at 3 p. m., a rumble not unlike distant thunder was heard, and at 3.06 p. m. a flash of lightning was seen and thunder heard east of the tornado cloud. The wind came from the south and the principal cloud formation kept moving from a west to a northwesterly direction.

As the cloud first neared the river its motion of translation appeared to be checked and the front of the cloud area presented a "rolled back" appearance and began to turn northward, the front of the heavy clouds curved in and out and took on the general outline of the west bank of the Hudson River beneath. On the opposite side of the river, and at about a distance of about 500 feet, comparatively bright weather conditions prevailed.

The storm moved northward for a short distance, thence northeast. As the cloud area or mass began to turn the wind began to feel peculiarly cool and the snow had a hard covering—no hail fell. The snow was partly covered with ice; it was hard, like a fish scale, on one side. The snow changed to rain at 3.02 p. m., and ended at 3.25 p. m. After the storm had passed away the observer visited the south end of the city, and at a point on Quay street at the river front found that the stack of the Townsend Furnace Company was broken, the broken part hanging along side of the standing part. Some roofing, slate, and debris were scattered in Mulberry street in a southwest direction. The observer next visited the Gould Carriage Works, and one of the office force, a member of the firm, stated that he first noticed that a peculiar darkness was coming on, and heavy clouds, low down, were appearing in the west. Shortly after 3 p. m. he heard a peculiar hissing noise, following which came a flash of lightning and a loud clap of thunder. The next thing he knew his office room was filled with dust, and he thought the whole building was coming down. The workmen were badly frightened and rushed down stairs. Immediately before the commotion in the building the air outside his office was filled with shingles, pieces of wood, old shoes, and glass, all of which were carried in a general northerly direction. The foreman led me to the roof of the works. I examined the roof of the building and found a section 50 by 10 feet ripped off. The building from which the tin was ripped off is 5 feet higher than the adjacent structures.

The tin was torn from the southwest corner of the building in a northerly direction and hurled against the south side of the stack of the Townsend Furnace Company on the opposite side of the street. The corner of the fence opposite the Gould Carriage Works was blown down. On the Story property the windows were broken. On the northeast corner of Dallius and Cherry streets I found that a piece was taken out of the southeast side of the northeast chimney on Mr. R. B. Rock's dwelling, also 20 feet of a fire wall on the south side of the

house was razed level with the roof, the structure and some bricks and coping carried away from the northwest corner of the building. Mr. Rock informed me that he had a coop on the roof which was carried away, and struck the chimney first and then the northwest corner of the roof, after which it fell to the sidewalk below. During or prior to the storm Mr. Rock was at the Aniline Works, on the corner of Vine street and Broadway, and he noticed heavy clouds moving from the west with the surface wind due south. Muddy water was scooped out from puddles in the streets and hurled for some distance. A 10-foot board fence and gate, also the broad roof of a small house farther east on Bassett street, were torn off and carried across the street, falling to the south. The north wall of a shed adjoining was pushed outward for some distance.

Mr. Landy, who was in Mr. Lynch's yard at the time of the storm, was pinned down by a heavy 10 by 12 foot gate. The river was choppy, and some boys stated that water was lifted out of the river. The water in the river was some 6 feet below the string piece that evening. Between 5.45 and 6 o'clock p. m., at the time when the observer was going over the ground traversed by the storm, dark clouds were seen forming west of Bassett street; they moved over the observer from the west. Some clouds were also moving from the south at about right angles to the west cloud area with clear sky between the two formations. In the merging process they survived and the resultant cloud area moved northward along the west bank of the Hudson. No thunder came from the tornado cloud proper; it presented a V-shaped, light appearance to the observer as it came head on. Amount of damage estimated at \$2,000.

The chart of the path of destruction, compiled by Mr. Sims, is omitted from this abstract.

II.—TORNADO, MARCH 20, 1895, AUGUSTA, GA.

The following report is by Mr. D. Fisher, Weather Bureau observer at Augusta, Ga.:

At 9 a. m. March 20, 1895, a tornado struck the southwest portion of the city, moving in a path from southwest to northeast, occupying five minutes in traveling over a territory $3\frac{1}{2}$ miles in length, thus having a progressive velocity of 42 miles per hour. The lower appendage of the cloud was similar in shape to a funnel and was distinctly seen by several persons; it was visible in the air at a distance varying from 50 to 150 feet above the ground. The tail or funnel while in midair was seen swinging violently from side to side, and the noise it made when near the earth resembled that emanating from a moving freight train at a distance. The atmospheric conditions preceding, attending, and for a short while following the storm were as follows: The clouds at 8 a. m. were of the stratus type, of a deep slate color, scudding along very low from south to north at a rapid rate, and presented a billowy or choppy appearance; humidity, 81 per cent; the southerly winds had a velocity of 10 miles per hour; the temperature was 65°; the air was quite warm and sultry, and while on the tower roof the observer experienced a peculiar sensation which almost approached exhaustion. The wind blew from the northeast until 5.40 a. m., east until 7.20 a. m., south until 9 a. m., then suddenly veered to west and northwest, increasing in force and attaining a maximum velocity of 22 miles from south at 8.55 a. m. The barometer was falling rapidly all morning, reading 29.46 at 9.20 a. m., quickly rising to 29.56 at 10.30 a. m., then falling again until 4 p. m., when the instrument indicated 29.43, after which a steady and rapid rise occurred. A light shower of rain had

fallen in early morning, to the extent of 0.03 inch; at 8.43 rain again commenced to fall, becoming heavy about 9 a. m.; this lasted for ten minutes, and then subsided to a light fall, ending 10.20 a. m. The thermometer rose slowly from 65° at 8 a. m. to 67° at 9 a. m., but by 11.30 a. m. dropped to 49°. No thunder or lightning occurred either before, after, or during the prevalence of the tornado.

The topography of the country around the outskirts of Augusta is for the most part very hilly; the city is almost surrounded by a circle of elevations, from 200 to 300 feet in altitude; to the southward, however, the ground is comparatively low, flat and boggy, and it was from this opening that the storm entered the city. (See Chart No. VIII.)

No. 1 on the map was the first point struck by the tornado, although it was seen moving over a dense growth of pines situated about one-half of a mile back of the storm, or southwest of this place; the clouds appeared intensely black, but no funnel was then noticed. At No. 1 three large pines were uprooted, and all lay in a northeast direction; the distance between the outer and inner trees was 100 yards. The tornado then jumped over the pavilion, and continued in the air until No. 2 was reached; a partial descent was here made, resulting in twisting off one-half of a medium-sized pine; the broken portion was carried some 80 feet forward (or to the northeast). About 600 yards south-southeast of No. 2 a secondary or minor tornado tore away a tin roof on the south end of the glass works. From No. 2 another jump in the air occurred, descending on No. 3, a small frame house which was blown away, leaving nothing except the flooring upon which the two occupants of the house were standing, neither of whom were in the least injured; the debris of this house was also carried to the front and lodged against another small house 50 feet distant. It was here that several persons saw the funnel distinctly before it struck No. 3; they were standing east of the track about 300 yards away, and it appeared to them to have a shape like smoke coming from the stack of a locomotive engine, very black in front (northeast) and much brighter in the rear (southwest); they heard a subdued, roaring noise, and noticed the appendage twisting and writhing, but none could identify the direction in which the whirl rotated. The tornado bounded over the small house that No. 3 was lodged against, and came down into a small grove of pines, prostrating 3 of them which were lying in a northeast direction and twisting off 1 tree 15 feet from its roots, which latter lay pointing east; the space of ground occupied by these 4 trees, while standing, was not over 40 feet square. The tornado now continued its course to No. 5, which was a 2-room frame house on the west side of Twelfth street and crushed it to pieces; inside were 3 small children, and when the wreck was removed the children were found uninjured. Here the tornado again ascended, but descended on No. 6, a small frame dwelling standing on the southwest corner of Third avenue and Ninth street; this house was swung from its pillars, and the south end carried 5 feet toward the east; this shows beyond a doubt that the tornado was whirling from left to right, or in a direction contrary to the movement of the hands of a watch [see note]. After passing this point the tornado bounded up and next struck No. 7, also a small frame house, tearing off 12 feet of the chimney and scattered the fencing in the rear of the house; here the track of the storm was about 50 yards wide; it also wrecked a 2-room house in front of, and opposite to, No. 7, and then jumped across and demolished a kitchen standing 15 feet in rear of No. 8. Thus far along the route of the

tornado the funnel was visible to many persons, but now the debris commenced flying fast and thick, covering the cloud to such an extent that nothing further could be seen of the funnel.

On Eighth street, west side (No. 9), between Gwinnett and Hopkins streets, the destruction was terrible; 8 small frame houses were literally torn to pieces and the fragments carried several hundred feet away but in the path of the storm. The track here was 50 yards wide; one house on the southwest corner of Eighth and Gwinnett escaped destruction, 4 houses on Eighth and Hall streets (No. 10), just opposite, and somewhat larger than those previously encountered, were terribly disfigured, 3 having the roofs carried away and the fourth almost razed to the ground; one of the roofs which was lifted into the air was carried forward so rapidly that when it struck Miller's Mill, having traveled at least 300 feet, it tore a large hole in the roof, but the storm itself had passed a little to the east of the mill building, tearing away some 200 feet of tin roofing on the adjoining buildings used for storing empty barrels, &c. Again making a long jump, No. 11 was reached; this structure is the roundhouse of the Central Railroad, and one-third of this was torn to pieces. Near this point another minor tornado developed, bursting out 140 feet of the east brick foundation of the Central Railroad machine shops (No. 12); this building is 50 feet wide and 160 feet long, and is located about 400 feet south of No. 11. The secondary storm continued in a north-northeast direction and tore away the tile roof of No. 13 (Perkins' old office), being the last seen of storm No. 3; it also was 50 yards wide. The main storm ascended after leaving No. 11, but came down and destroyed a small frame house (No. 14) on the south side of Fenwick street, between Fifth and Sixth streets, jumped back again into the air, and visited the front yard (No. 15) of Mrs. H. T. Russell on the south side of Walker street, between Fourth and Fifth streets. Here it rooted up and scattered about all the shrubbery in the yard and blew down on the sidewalk an immense water-oak tree, one of the oldest and probably as large as any tree in the city. It was 5 feet in diameter and fully 100 feet high; the fallen tree lay in a northeast direction. Again bounding up the storm crossed over and struck down a medium-sized tree standing on the west side of Fourth street, north of Walker street; this tree lay pointing toward the east. It is believed that at this point the tornado entirely disappeared.

[NOTE.—When any obstacle, house, or stone is pushed straight ahead by a uniform force, such as the pressure of a very uniform straight-lined gale, the movement of that obstacle is not necessarily in a straight line, but depends upon the shape of the obstacle and the resistance met with as it endeavors to move along the earth's surface. If, for instance, one end of the small frame building, No. 6, was more heavily loaded or more firmly fastened than the other end, or if some fastenings gave way last and after the other end had begun to move, then the final position of the building would make an angle with its original position; the building will have been twisted around, although the wind that struck it was blowing in a straight line; therefore, the conclusion as above drawn by Mr. Fisher seems open to revision.—C. A.]

NOTES BY THE EDITOR.

SENSIBLE TEMPERATURES.

As this term has been used by several persons with different significations it may be worth while to recall these and compare the definitions among themselves. In the Philosophical Transactions for 1826 of the Royal Society of London, Dr. W. Heberden advanced the idea that sensible cold depended on the rate at which the internal heat is carried off from the surface of the body. Assuming that the surface of a thermometer is analogous to that of the body he proposed to use its rate of cooling as an index to the sensible temperature. He, therefore, warmed a thermometer to about 120° F., and allowed it to cool in the wind; the time required for it to cool from 100° down to 80°, or the amount by which it cooled in ten seconds, constituted, according to him, a measure of the sensible cold. [The rate of fall of the column of mercury depends largely on the internal resistance of the capillary tube, and the method is therefore not a correct measure of the cooling of the surface of the bulb.]

About 1871, Mr. J. W. Osborne, of Washington, proposed to use the cooling surface of a paper cylinder that was filled with water; the mass of water was about 4 pounds in weight, and

as it was kept well stirred the temperature could be accurately given by means of a thermometer. The ratio of the mass to the cooling surface was about the same as that in the human body. He proposed to determine the time required for this mass of water to fall 1° in temperature after it had been warmed to a little above blood heat. In order to distinguish between the influence of atmospheric temperature and vapor he made similar observations with a cylinder of water whose surface was always kept dry. As the results of his experiments he found that the sensible temperature affecting human beings is very different from that given by the ordinary thermometer; that the fluctuations in it are far greater than most persons have any idea of; that there are sudden oscillations quite as important as the great changes from day to day; that the wind is often more important than the temperature; and that it causes the instantaneous oscillations. The rate at which the cylinder of water loses its temperature is proportional to the rate at which the human body must supply heat in order to maintain its own constant temperature, and this rate is the basis of our conception of sensible temperature. By securing the cooperation of a large num-